

AMENDMENTS TO THE CLAIMS

This listing of claims replaces all prior versions of claims in the application.

1. (Currently Amended) A device for driving a solenoid, comprising:
 - a power supply;
 - a switching element connected between said power supply and said solenoid in series therewith;
 - a current circulating diode connected in parallel to a series circuit comprising said solenoid so that the cathode of said current circulating diode is connected between said switching element and said solenoid;
 - a current detecting circuit for detecting an actual current flowing through said solenoid;
 - PID computing means for computing an on-duty value and an off-duty value according to a difference between a target current and said actual current detected by said current detecting circuit, and outputting said on-duty value and said off-duty value;
 - PWM duty driving means for generating a PWM duty signal according to inputting of said on-duty value and supplying said PWM duty signal to said switching element to on/off control said switching element; and
 - a reverse voltage applying means comprising:
 - a second switching element connected between the negative electrode of said power supply and said solenoid in series therewith;

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a second current circulating diode connected in parallel to a series circuit composed of said switching element and said solenoid so that the cathode of said second current circulating diode is connected between said power supply and said switching element;

an absolute value calculating means for calculating the absolute values of said on-duty value and said off-duty value;

an inverter for inverting the signs of said on-duty value and said off-duty value;

a NAND circuit adapted to input an output from said absolute value calculating means and an output from said inverter; and

a driver circuit for on/off controlling said second switching element according to an output from said NAND circuit, wherein

said reverse voltage applying means is capable of applying a voltage of said power supply as a reverse voltage to said solenoid according to inputting of said off-duty value when said switching element is off.

2-5 (Canceled).

6. (Original) A device according to claim 1, wherein said PID computing means comprises:
integral term calculating means for calculating an integral term according to the
difference between said target current and said actual current; and
means for resetting said integral term to 0 when said actual current becomes a
predetermined value or less.

7. (Original) A device according to claim 1, wherein said power supply comprises a single
power supply.

8. (Currently Amended) A device for driving an electromagnetic actuator including a
ringlike core member having an annular groove, an annular solenoid accommodated in said
annular groove of said core member, and a ringlike armature member opposed to said core
member with a given gap defined therebetween, said device comprising:
a power supply;
a switching element connected between said power supply and said solenoid in series
therewith;
a current circulating diode connected in parallel to a series circuit comprising said
solenoid so that the cathode of said current circulating diode is connected between said switching
element and said solenoid;
a current detecting circuit for detecting an actual current flowing through said solenoid;

PID computing means for computing an on-duty value and an off-duty value according to a difference between a target current and said actual current detected by said current detecting circuit, and outputting said on-duty value and said off-duty value;

PWM duty driving means for generating a PWM duty signal according to inputting of said on-duty value and supplying said PWM duty signal to said switching element to on/off control said switching element; and

a reverse voltage applying means comprising:

a second switching element connected between the negative electrode of said power supply and said solenoid in series therewith;

a second current circulating diode connected in parallel to a series circuit composed of said switching element and said solenoid so that the cathode of said second current circulating diode is connected between said power supply and said switching element;

absolute value calculating means for calculating the absolute values of said on-duty value and said off-duty value;

an inverter for inverting the signs of said on-duty value and said off-duty value;

a NAND circuit adapted to input an output from said absolute value calculating means and an output from said inverter; and

a driver circuit for on/off controlling said second switching element according to an output from said NAND circuit, wherein

said reverse voltage applying means is capable of applying a voltage of said power supply

as a reverse voltage to said solenoid according to inputting of said off-duty value when said switching element is off.

9-12 (Canceled)

13. (Original) A device according to claim 8, wherein said PID computing means comprises:
integral term calculating means for calculating an
integral term according to the difference between said target current and said actual current; and
means for resetting said integral term to 0 when said actual current becomes a
predetermined value or less.

14. (Original) A device according to claim 8, wherein said power supply comprises a single
power supply.

15. (Currently Amended) A control device for an electromagnetic actuator including a core
member having a groove, a solenoid accommodated in said groove of said core member, and an
armature member opposed to said core member with a gap defined therebetween, said control
device comprising:

gap detecting means for detecting said gap between said core member and said armature
member;

current detecting means for detecting an actual current flowing through said solenoid;
a feedback controller for feedback controlling said actual current so that said actual current becomes equal to a target current;
a feedforward controller for feedforward controlling said target current; and
solenoid drive signal generating means for generating a solenoid drive signal according to outputs from said feedback controller and said feedforward controller;
said feedback controller changing an integral term constant according to said gap detected by said gap detecting means;
said feedback controller selects one of a plurality of predetermined integral term constants according to said gap detected by said gap detecting means; whereby said feedback controller selects a larger one of said integral term constants when said gap is large, and selects a smaller one of said integral term constants when said gap becomes smaller.

16-17 (Canceled)

18. (Original) A control device according to claim 15, wherein said feedforward controller changes a transfer function and/or a gain according to said gap detected by said gap detecting means.

19. (Original) A control device according to claim 18, wherein said feedforward controller selects one of a plurality of predetermined transfer functions and/or one of a plurality of predetermined gains according to said gap detected by said gap detecting means.

20. (Original) A control device according to claim 19, wherein said feedforward controller selects a smaller one of said transfer functions and/or a smaller one of said gains when said gap is large, and selects a larger one of said transfer functions and/or a larger one of said gains when said gap becomes smaller.

21. (Original) A control device according to claim 15, wherein said gap detecting means comprises a magnetic flux sensor for detecting a magnetic flux intensity generated from said solenoid.

22. (Original) A control device according to claim 15, further comprising a target filter provided on the front stage of said feedback controller and adapted to input said target current.

23. (Currently Amended) A control device for an electromagnetic actuator including a core member having a groove, a solenoid accommodated in said groove of said core member, and an armature member opposed to said core member with a gap defined therebetween, said control device comprising:

gap detecting means for detecting said gap between said core member and said armature member;

current detecting means for detecting an actual current flowing through said solenoid;

a feedback controller for feedback controlling said actual current so that said actual current becomes equal to a target current;

a feedforward controller for feedforward controlling said target current; and

solenoid drive signal generating means for generating a solenoid drive signal according to outputs from said feedback controller and said feedforward controller;

said feedforward controller changing a transfer function and/or a gain according to said gap detected by said gap detecting means;

said feedforward controller selects one of a plurality of predetermined transfer functions and/or one of a plurality of predetermined gains according to said gap detected by said gap detecting means, whereby said feedforward controller selects a smaller one of said transfer functions and/or a smaller one of said gains when said gap is large, and selects a larger one of said transfer functions and/or a larger one of said gains when said gap becomes smaller.

24-25 (Canceled)

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26. (Original) A control device according to claim 23, wherein said gap detecting means comprises a magnetic flux sensor for detecting a magnetic flux intensity generated from said solenoid.

27. (Original) A control device according to claim 23, further comprising a target filter provided on the front stage of said feedback controller and adapted to input said target current.